The Specification has been amended at page 9, line 7 to correct a minor typographical omission. No new matter has been introduced by way of the proposed change to the Specification.

The Claims

Claims 1-24 are pending in the present application; original claims 1-20 have been amended, and claims 21-24 added. The foregoing claim amendments do not introduce any new matter, and are not intended to limit, restrict or otherwise preclude applicant from asserting any subsequent patent rights under the judicially recognized doctrine of equivalents.

Claim Rejections Under 35 U.S.C. § 112, ¶ 2

Claims 1-20 have been rejected under 35 U.S.C. § 112, paragraph 2, as being indefinite for failing to particularly point out and distinctly claim the subject matter of the present invention. Applicants respectfully disagree, and will now address each of the Examiner's questions in turn.

Regarding claim 1, applicants use the term "expander" to refer to a device or assembly "effective to generate torque and lower the pressure of the pressurized gas which is communicated to the fuel cell." (See, e.g., Specification at p. 4, lines 3-8.) In a preferred but non-limiting embodiment, as described for example in the Specification on page 7, line 2, the expander includes an expander turbine. (See also, e.g., Specification at Claim 13.) Similarly, in a preferred but non-limiting embodiment, the compressor may include a compressor turbine. (See, e.g., Specification at Claim 12.) Both the expander and the compressor, however, as known and appreciated by those in the art, may include a piston, screw device or other equivalent device to produce the same or similar results.

With respect to the Examiner's question as to which components are generating torque, claim 1 makes clear that the expander generates a torque, which is in turn transmitted to the electric machine for generating electrical power.

As for the remainder of claim 1, and claims 5 and 6, applicants have amended the claims to remove the language questioned by the Examiner.

Based on the foregoing, claims 1-20 as amended are believed to be in full compliance with 35 U.S.C. § 112, ¶ 2.

Claim Rejections Under 35 U.S.C. § 103(a)

Claims 1-20 have also been rejected under 35 U.S.C. § 103(a) as being obvious over U.S. Patent No. 6,370,050 to Peng et al. in view of U.S. Patent No. 4,281,256 to Aherns et al. and U.S. Patent No. 5,991,670 to Mufford et al. Applicants respectfully disagree and submit that the pending claims are not rendered obvious by the combination of references proposed by the Examiner.

The claimed invention, as set forth in new claim 21, relates to a method for operating a vehicle having a fuel cell system and at least one electric machine, wherein the fuel cell system is powered at least in part by a combination of air and pressurized gas fuel. The method includes the steps of lowering the pressure of the pressurized gas fuel in order to operate the fuel cell system and recover an amount of potential energy from the pressurized gas fuel in the form of a mechanical driving force for the electric machine, and applying at least a portion of the driving force directly to the electric machine to generate electrical power.

Advantageously, the generated electrical power can be used to raise the pressure of the air used to operate the fuel

cell system, or to power other vehicle electrical loads. Still advantageously, at least a portion of the generated electrical power can be stored for later use.

A corresponding system, as set forth in amended claim 1, includes an expander, a compressor and an electric machine. The expander is used for lowering the pressure of the gas and for generating a torque, i.e., a mechanical driving force, for driving the electric machine. The compressor is used to raise the pressure of the air. Advantageously, the electric machine uses the torque generated by the expander to generate electrical power for the compressor.

The primary reference cited by the Examiner, Peng et al., is directed a power conversion circuit for use in electric and hybrid electric vehicles, including fuel cell vehicles. (U.S. Patent No. 6,370,050 at Abstract.) Although the reference includes a schematic of a fuel cell vehicle system having a compressor motor expanding unit (CMEU) coupled to a fuel cell, e.g., U.S. Patent No. 6,370,050 at Figure 2A, Peng et. al do not teach or even suggest the steps of lowering the pressure of the gas in order to recover an amount of potential energy in the form of a mechanical driving force, and applying the mechanical driving force directly to an electric machine to generate electrical power.

Peng et al. in fact teach away from the claimed invention by omitting an electric generator altogether, and by showing no direct coupling between the CMEU 24 and the electric motor 28. (U.S. Patent No. 6,370,050 at Figure 2A.)

Similarly, the secondary references cited by the Examiner fail to teach or even suggest the steps of the present invention. Aherns et al. discloses a reciprocating engine that is operated as an expander during peak demand periods and as a compressor during slack demand periods. (U.S. Patent No. 4,281,256 at Col. 2, line 66 - Col. 3, line

7.) Mufford et al. discloses a power and reactant supply control system for a fuel cell electric power generation system. (U.S. Patent No. 5,991,670 at Col. 1, lines 13-17.) Primarily because Aherns et al. and Mufford et al. address completely different problems, there is no teaching or suggestion to combine either of the secondary references with Peng et. al for the purpose of recovering potential energy from a pressurized gas fuel and using the recovered potential energy directly to produce electrical energy.

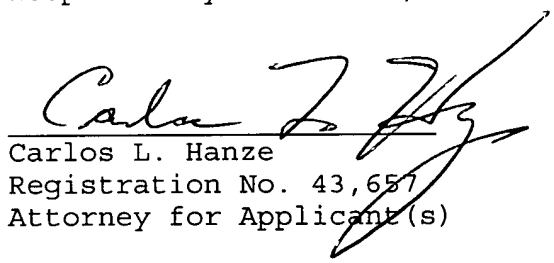
Applicants respectfully submit that pending claims 1-24, including amended claims 1-20 and new claims 21-24, are allowable over the combination of the Peng et al., Aherns et al. and Mufford et al. references urged by the Examiner. The Peng et al. reference, whether taken singly or in combination, for example fails to teach or even suggest the steps of lowering the pressure of the gas fuel to recover an amount of potential energy in the form of a mechanical driving force, and applying at least a portion of the driving force directly to an electric machine to generate electrical power. Because there is no suggest or motivation to combine, the combination of references proposed by the Examiner would amount to impermissible hindsight reconstruction of the claimed invention.

Accordingly, the above-identified application is believed to be in condition for allowance in all respects, and such allowance is courteously solicited.

If any further amendment is necessary to advance prosecution and place this case in allowable condition, the Examiner is courteously requested to contact the undersigned by fax or telephone at the number listed below. Please charge any cost incurred in the filing of this Amendment, along with any other costs, to Deposit

Account 06-1510. If there are insufficient funds in this account, please charge the fees to Deposit Account No. 06-1505.

Respectfully submitted,



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Enclosure

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MARKED-UP VERSION TO SHOW CHANGES MADE

The Specification

The paragraph beginning on page 8, line 25 is amended as follows:

Fuel tank 16 is a conventional storage tank which is adapted to receive and store compressed gaseous fuel, such as hydrogen gas, at relatively high pressures. In the preferred embodiment, expander 18 is a conventional turbine which selectively receives and which is rotatably driven by pressurized gas delivered from tank 16. Expander turbine 18 is selectively and operatively coupled to motor/generator 76 by use of shaft 80 and to compressor turbine 20 by use of shaft 80, a conventional clutch 84 and a shaft 82 which is coupled to compressor turbine 20. In one alternate embodiment, expander turbine 18 and compressor turbine 20 are connected by a single shaft. When expander turbine 18 and compressor turbine 20 are mechanically coupled together by use of clutch 84, the rotation or torque produced by expander turbine 18 drives compressor turbine 20. This rotation/torque can also be selectively used by the motor/generator to generate electrical energy in a conventional manner. After passing through expander turbine 18, the hydrogen gas is communicated to fuel cell 12 by way of conduits 44, 42, 46 and regulator 22.

The Claims

Claims 1-20 are amended as follows:

1. (Amended) A system for recovering potential energy from a pressurized gas fuel supply which is used to power a fuel cell within a vehicle, said system comprising:

a fuel tank [which stores] for storing pressurized gas fuel;

a first conduit system [which] for selectively and fluidly [couples] coupling said fuel tank to [said] the fuel cell, [effective to allow said] and for allowing the pressurized gas fuel to be selectively communicated to [said] the fuel cell;

an expander [including a turbine which is] disposed within said first conduit system and which is selectively [and rotatably] driven by [said] the pressurized gas fuel, [effective to generate] for generating torque and [lower] lowering the pressure of [said] the pressurized gas fuel which is communicated to [said] the fuel cell;

a second conduit system [which] for selectively and fluidly [couples said] coupling the fuel cell to a source of air, [effective to allow said] and for allowing the air to be selectively communicated to [said] the fuel cell;

a compressor [which is] disposed within said second conduit system and which is selectively coupled to and driven by said expander, [said compressor being effective to pressurize said] for pressurizing the air which is communicated to [said] fuel cell; and

an electric machine [which is] operatively coupled to said expander and to said compressor, [said electric machine being effective to] for selectively [convert] converting torque generated by said expander into electrical power, and [to] for selectively [convert] converting electrical power into [mechanical torque for] to [rotatably driving] drive said compressor.

2. (Amended) The system [of] according to claim 1, further comprising [a source of] an electrical [power which is] power source selectively coupled to said electric machine.

3. (Amended) The system [of] according to claim [2] 1, further comprising a bypass valve [which is effective to cause

said] for causing the pressurized gas fuel to selectively bypass said expander.

4. (Amended) The system [of] according to claim 3, further comprising:

at least one sensor [that is effective to measure] for measuring at least one vehicle operating attribute and [to generate] for generating a signal representing [said] the measured vehicle operating attribute; and

a controller [which is communicatively] coupled to said bypass valve and to said at least one sensor, [said controller being effective to receive said] for receiving the signal and [to] for selectively [control said] controlling the bypass valve based upon the value of [said] the signal.

5. (Amended) The system [of] according to claim 4, further comprising[:]

a switching module [which is electrically and communicatively] coupled to said controller and [which is electrically coupled to] a plurality of electrical components[;

wherein said controller selectively controls said switching module, effective], said switching module being selectively controlled by said controller to selectively transfer [said] the generated power from the electric machine to one or more of said plurality of electrical components.

6. (Amended) The system [of] according to claim 5, wherein said controller [is further effective to] selectively and electrically [connect] connects said electric machine to said [source of] electrical power source by use of said switching module.

7. (Amended) The system [of] according to claim 1, further comprising[:] at least one pressure-reducing regulator [which is] disposed within said first conduit system.

8. (Amended) A system for supplying pressurized hydrogen gas and air to a fuel cell within a vehicle, said system comprising:

a fuel tank [which stores said] for storing the pressurized hydrogen gas;

a first conduit system [which] for selectively and fluidly [couples] coupling said fuel tank to [said] the fuel cell, [effective to allow said] and for allowing the pressurized hydrogen gas to be selectively communicated to said fuel cell;

a motor/generator for selectively converting torque into electrical power, and for selectively converting electrical power into mechanical torque;

a source of electrical power [which is] selectively connected to said motor/generator [and which] for selectively [provides] providing electrical power to said motor/generator;

an expander [which is] disposed within said first conduit system, [which is] and operatively coupled to said motor/generator, and which is selectively and rotatably driven by [said] the pressurized hydrogen gas, [effective to lower] for lowering the pressure of [said] the pressurized hydrogen gas [which is] communicated to [said] the fuel cell and [to cause] for causing said [generator] motor/generator to produce electrical power;

a second conduit system [which] for fluidly [couples] coupling [said] the fuel cell to a source of air, [effective to allow said] and for allowing the air to be selectively communicated to [said] the fuel cell;

a compressor [which is] disposed within said second conduit system, [which is] and operatively coupled to said motor/generator, and which is selectively and operatively coupled to said expander, said compressor being selectively and rotatably driven by said expander and by said motor/generator, for [and being effective to pressurize] pressurizing said air within said second conduit system; and

a clutch [which] for selectively [connects] connecting and [disconnects] disconnecting said expander and said compressor.

9. (Amended) The system [of] according to claim 8, further comprising:

a bypass valve [which is] disposed within said first conduit system [and which is effective to cause said] for causing the pressurized hydrogen gas to selectively bypass said expander; and

a controller [which is communicatively] connected to said bypass valve [and which] for selectively [actuates] actuating said bypass valve, [effective to cause said] and for causing the pressurized hydrogen gas to selectively bypass said expander.

10. (Amended) The system [of] according to claim 9, wherein said controller is further connected to said motor/generator [and which is effective to cause] for causing said motor/generator to drive said compressor when [said] the pressurized hydrogen gas bypasses said expander.

11. (Amended) The system [of] according to claim 10, further comprising:

a plurality of sensors [which are effective to measure] for measuring vehicle operating attributes and [to generate] for generating signals representing said measured vehicle operating attributes; and

wherein said controller is [communicatively] coupled to said plurality of sensors, and wherein said controller receives [and is effective to receive] said signals and [to] selectively [actuate] actuates said bypass valve based upon the value of said signals.

12. (Amended) The system [of] according to claim [10] 8, wherein said compressor comprises a turbine.

13. (Amended) The system [of] according to claim [10] 8, wherein said expander comprises a turbine.

14. (Amended) A method for recovering potential energy stored within a pressurized gas used to power a fuel cell within a vehicle, said method comprising [the steps of]:

providing a first conduit system for transferring said pressurized gas to [said] the fuel cell;

providing an expander;

operatively disposing said expander within said first conduit system;

providing a motor/generator for producing electrical power from torque and for producing torque from electrical power;

providing a second conduit system for transferring air to [said] the fuel cell;

providing a compressor;

operatively disposing said compressor within said second conduit system;

operatively connecting said expander and said compressor to said motor/generator;

selectively connecting said expander and said compressor; and

channeling said pressurized gas through said expander[, effective] so as to rotatably drive said expander, thereby selectively driving said compressor and selectively causing said motor/generator to produce electrical power.

15. (Amended) The method [of] according to claim 14, further comprising [the steps of]:

measuring a vehicle operating attribute;

selectively causing [said] the pressurized gas to bypass said expander[,] based upon said measured vehicle operating attribute.

16. (Amended) The method [of] according to claim 15, further comprising [the steps of]:

providing a source of electrical power; and

connecting said source of electrical power to said motor/generator when [said] the pressurized gas bypasses said expander, [effective to cause] thereby causing said motor/generator to produce torque and rotatably [drive] driving said compressor.

17. (Amended) The method of] according to claim 16, further comprising the step of[:] disconnecting said compressor from said expander when said pressurized gas bypasses said expander.

18. (Amended) The method [of] according to claim 16, wherein said vehicle operating attribute comprises a pressure of [said] the pressurized gas in a certain location within said conduit system.

19. (Amended) The method [of] according to claim 16, wherein said source of electrical power comprises a battery.

20. (Amended) The method [of] according to claim 19, further comprising the step of[:] delivering [said] the produced electrical power to said battery effective to recharge said battery.